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RESEARCH ARTICLE

Assessing the Evidence Base for Restoration in South Africa

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Abstract

If restoration is to become effective, able to compete for limited funds and truly adaptive, it must become evidence-based. Three of the conditions essential for the establishment and advancement of evidence-based restoration are (1) collection of baseline information; (2) setting clearly defined goals; and (3) relevant and adequate monitoring. Using a literature review, complemented with an online survey, we reviewed 10 restoration programs in South Africa to assess whether current restoration practice meets these conditions. The review showed good collection of baseline information and the setting of restoration goals that span ecological and socioeconomic considerations. However, to a large extent goals were poorly defined, there was more monitoring of inputs than outcomes, and monitoring of ecological indicators was inconsistent. These shortcomings can undermine restoration impacts, as well as the future sustainability of these expensive programs. We conclude with recommendations on how to mainstream the requirements of evidence-based restoration into current and proposed restoration programs.

Key words: baseline information, evidence-based practice, goal setting, monitoring.

Introduction

Evidence-based practice emerged in the 1980s in medicine (Rosenberg & Donald 1995) and is defined as the process of systematically finding, appraising, and using evidence to demonstrate the effectiveness of a specific intervention in decision-making. Calls for evidence-based practice have been made in conservation (Salafsky et al. 2002; Pullin et al. 2004; Sutherland et al. 2004; Ferraro & Patanayak 2006). The need for evidence-based conservation has never been more pressing than currently, when several nations have set themselves the ambitious target of halting or significantly reducing the current rate of biodiversity loss at various scales by 2010 (UNEP 2002). In order to achieve this and other related conservation targets, some pertinent questions need to be addressed: (1) What should our goals be and how do we measure progress in reaching them?, (2) How can we learn to do conservation better? (Salafsky et al. 2002), and (3) How can we benefit and adapt management approaches from the experience gained from success and failure? (Folke et al. 2005; Knight 2006; Hobbs 2009). These questions essentially lay the foundation for evidence-based conservation.

Restoration can benefit from being evidence-based. Because the practice is inherently expensive, for it to compete for funding with other budgetary priorities, practitioners need to justify the expense with solid evidence rather than anecdotes. In addition, the provision of ecosystem services is often stated as one of the rationales for undertaking restoration. The aim is usually to tap into the emerging global market for ecosystem services, the payments for ecosystem services (PES) market. PES compensates individuals or communities for undertaking actions that increase the provision of ecosystem services (Jack et al. 2008). Sellers of "enhanced" ecosystem services need to demonstrate to the buyers that there has indeed been an improvement in the provision of the ecosystem service being bought, and that the improvement is directly attributable to the intervention. Such demonstration of effectiveness can be achieved through adopting an evidence-based approach to restoration.

Restoration is widely practiced in South Africa, at scales ranging from local to landscape. The cumulative associated annual expenditure ranges in tens of millions of US dollars (Preston & Williams 2003; Kotze & Ellery 2008). For example, the Working for Water program, a national restoration program aimed at simultaneously controlling alien invasive plant species to provide water benefits while creating employment (Van Wilgen et al. 1998), has an annual budget of about $US 59 million (DWAF 2007). It has been hailed internationally as a success (Hobbs 2004), has received various awards (Common Ground 2003), and has been used locally as a model for newer, related programs. South African restoration programs thus provide a good platform from which evidence-based restoration can be assessed. This study does

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that by examining the relationship(s) between restoration goals and the monitoring data collected to assess progress toward their achievement, using 10 restoration programs. We ask the following key questions: (1) What are the primary goals of restoration?, (2) What baseline data are collected prior to restoration efforts?, and (3) What types of indicators are used in monitoring and at what temporal and spatial scales?

Methods

Restoration Program Review

Names of restoration programs that were known to the authors were used to search for information using the following search engines: ScienceDirect, Google Scholar, and Google. These programs included Working for Water, Working for Wetlands, Working for Woodlands, LandCare South Africa, and one post-mining restoration program.[1] The Working for Woodlands program was disaggregated into its six constituent subprograms, each of which had different goals and approaches. We chose to assess three of these subprograms, treating them as individual programs viz the Subtropical Thicket Restoration Project (STRP), the African Rural Initiatives for Sustainable Environments (ARISE) project, and the Matiwane forest restoration project. We deliberately excluded the Fynbos Riparian Restoration project and the St. Francis Thatch project because they were not aligned with the primary focus of the Working for Woodlands program, which is to regain woodland composition, structure, and function. We also excluded the Sekhukhune Lands Intervention Programme because we were unable to obtain sufficient information on it.

The same search engines were used to find more restoration programs for possible inclusion in the assessment. The search phrases were different combinations of terms from the following groups of terms: group 1 (ecological, post-mining, and rangeland), group 2 (restoration, rehabilitation, and revegetation), and group 3 (project/s and program/s). The phrase "South Africa" was used as a suffix in all the search combinations. Relevant results from the first 20 hits of each search were considered further, e.g. if a result referred to a restoration program in South Africa, more information on the program was sought and the program was included or excluded from the assessment based on the inclusion criteria listed below. Where insufficient information was available from the sources found during the information search, contact was established with program managers and/or coordinators to seek further information on those particular programs. We ended up with a total of 10 restoration programs for the assessment, the descriptions of which are contained in Table S1 (Supporting Information), together with sources of more information on these programs.

Program Inclusion Criteria

Only programs that met the following criteria were included in the assessment:

(1) terrestrial restoration
(2) aimed to fulfill (1) socioeconomic and ecological goals and/or (2) legal obligations
(3) had been operational (i.e. had been implemented) for 2 years or more.

We included both assisted regeneration (McDonald 2000) and active restoration programs. Assisted regeneration, in this instance, referred to the removal or exclusion of the degrading agent, without subsequent active manipulation to stimulate system recovery. System recovery was assumed to have happened through ecological succession. Examples in this category included alien plant removal and erection of fences around degraded areas to reduce trampling by animals. Active restoration referred to intentional and physical manipulation of the system to kick-start recovery. This is what the Society for Ecological Restoration referred to as ecological restoration in its first version of the Primer on Ecological Restoration (SER 2004).

We deliberately excluded research-driven restoration projects (i.e. restoration projects whose only goal was research) from the assessment for two reasons: (1) by their very nature, such projects have well-designed monitoring programs, which could give the impression that monitoring is widespread, which may not necessarily be the case in non-research-based projects and (2) research-driven projects generally lack long-term, wider socioeconomic goals and tend to focus on testing specific biophysical hypotheses. However, research projects that were associated with, and formed part of, larger restoration initiatives were included under their "parent" programs.

Information Sources

Information sources used included online newsletters, electronic databases, technical reports, periodic (primarily annual) reports, business plans, student dissertations, and published research papers.

Information Extracted

The following information was extracted from the information sources: type of restoration (e.g. active or assisted regeneration), goals of restoration, commencement (year), baseline data collected, indicators monitored, monitoring intervals, and associated research component.

Web-Based Survey

To supplement the information gathered through the desktop study, we conducted a survey among managers and researchers closely involved in the programs we were going to assess. A computerized, self-administered questionnaire (CSAQ) was sent to the respondents by e-mail. We used this method to do the survey because it is cheaper and quicker than conventional techniques (Babbie & Mouton 2001), and secondly because the target respondents were able to understand the questions and therefore complete the survey unassisted. The respondents were required to answer the following questions: (1) What are the goals of the restoration program you are involved in?,

[1]For confidentiality reasons, the name of the mining companies undertaking restoration programs assessed in this study cannot be publicized.

(2) What baseline data are collected prior to restoration?, and (3) What indicators are monitored and at what temporal and spatial scales?

We used responses from two or three respondents in each program except for the Matiwane forest restoration project, rangeland restoration, and community-based restoration. For each of these three programs, we only had one respondent who had completed the survey.

Data Analysis and Presentation

In order to analyze the data and present the results, we grouped projects using the rules below. Projects that did not fall within a recognized formal restoration program were subjectively categorized based on administrative/land use context: commercial farming land, protected areas, mined areas, and communal areas. In order to be included in the analysis, goals and indicators used had to be cited in literature and by all respondents from a particular program. Distinction was made between indicators used at all project sites and those used only at selected sites. If there was disagreement between the respondents from a single program and/or literature about the spatial scale at which an indicator was monitored, then that indicator was classified as "inconsistently monitored." Such indicators were classified together with those that were monitored at selected sites or only as part of short-term studies.

Program goals and indicators were classified as either "socioeconomic" or "ecological." "Socioeconomic" goals and indicators were those that had an economic/financial and social basis, while the "ecological" category included ecological, biological, chemical, physical, and hydrological considerations. Indicators were also categorized as either input- or outcome-based. Input-based indicators were those that focused on the intervention and not on its outcome. Typically, these indicators answer the question "what was done?," and can only be used for the duration of the active stage of a restoration program. In contrast, outcome-based indicators can be used to assess the impact of the intervention past its active stage and can be used to address the question "what are the sustained impacts of the intervention"?

We further distinguished between "implementation" and "impact" monitoring, where the former was defined as monitoring where input-based indicators were used, while the latter was where outcome-based indicators were used. To assess the extent of impact monitoring, we used the most directly relevant indicator in instances where there was more than one outcome-based indicator per goal. For example, the goal "soil conservation" could be monitored using both "plant survival/establishment" and "soil erodibility." In this instance, we used the latter indicator.

Data were used to produce histograms in Microsoft Office Excel 2003 (Microsoft Corporation, Redmond, WA, U.S.A.).

Results

Goals of Restoration

There were 14 goals of restoration cited across the 10 restoration programs we assessed, 8 of which were of an ecological nature (the uppermost 8), while the remaining 6 were socioeconomic (Table 1). The sum total of goals across all the 10 programs was 99, implying that each program had, on average, about nine goals. The most common ecological goal was ecosystem productivity improvement, stated in 9 of the 10 programs. This was followed by soil conservation, stated in eight programs. Water resource improvement, biodiversity conservation, and restoring natural capital were each cited in seven programs. The broad goal, "increasing resilience," was cited in six programs. In terms of socioeconomic goals, job creation and capacity building were the most common goals, stated in 9 of the 10 programs. Poverty alleviation, livelihood improvement, and environmental awareness creation ranked second, stated in eight programs, with the development of a market for PES considered in four programs. Overall, of the 14 goals listed, 7 were qualitative in nature.

Baseline Data

Baseline information collection appeared to be a common practice, evidenced by the proliferation of types of baseline data collected in association with each goal (Table 1). Two of the goals, however, had no baseline data associated with them. Some goals were each associated with up to three types of baseline data.

Ecological baseline data were collected in more programs than those which had ecological goals aligned to them. For example, baseline data on invasive alien species (IAS) parameters were collected in eight programs, while only five programs cited IAS management as a goal. In contrast, socioeconomic baseline data were collected in fewer programs than those which cited the associated goals.

Monitoring and Indicators Used

Indicators used to monitor progress toward the achievement of goals are listed in Table 1 (column 3). There were 17 types of indicators. The higher number of indicators relative to the number of goals (17 vs. 14) can be attributed to the occasional use of more than one indicator per goal. For example, the indicators "solid structures built" and "areas revegetated" could both be used for the "soil conservation" goal, whereas "number of jobs created" and "person hours worked" could both be used for the "job creation" goal.

Overall, socioeconomic indicators were monitored more consistently than ecological indicators (Fig. 1). For example, the most common ecological indicator, "area revegetated" was used in eight programs in total, but was only monitored consistently in three of those eight programs. In contrast, the most common socioeconomic indicators "person hours worked" and "training provided" were also used in eight programs, but were monitored consistently in six and five programs, respectively. In addition, the most common ecological indicator was input-based, making it of limited use in determining the success of restoration efforts. Indeed, 50 and 36% of socioeconomic and ecological indicators, respectively, were input-based.

Table 1. Goals of restoration, together with baseline information and indicators associated with them.

Goal	*Baseline*	*Indicator/s*
Ecosystem productivity improvement (9)	Soil chemical quality (6) Plant species composition (9)	Biomass accumulation (3)
Soil conservation (8)	Geomorphology (7) Extent of erosion/bare patches (8) Levels of degradation (9)	Solid structures built[a] (3) Plant survival/establishment (6) Area revegetated[a] (8) Soil erodibility (5)
Biodiversity conservation (7)	Density/cover of indigenous species (9) Plant species composition (9)	Biodiversity indicators (5) Area revegetated[a] (8)
Water resource improvement (7)	Water quality (8) Water quantity (7) Aquatic diversity (7)	Water quality/quantity (2)
Alien plant control (5)	IAS identity, distribution and/or density (8)	Area cleared of IAS[a] (5) Soil seed banks (3) Post-clearing follow-up treatment[a] (1)
Carbon sequestration (4)	Carbon stocks (7)	Carbon sequestered (2)
Increasing resilience (6)	—	—
Restoring natural capital (7)	—	—
Job creation (9)	Unemployment rate (7)	Number of jobs created (7) Person hours worked[a] (8)
Poverty alleviation (8)	People living in poverty (6) Household income (6)	—
Livelihood improvement (8)	Household income (6) Informal harvesting (1)	Livelihood impacts (3)
Capacity building (8)	Literacy (5)	Training provided[a] (8)
Development of a market for PES (4)	Carbon stocks (7)	Carbon sequestered (2)
Environmental awareness creation (8)	Environmental awareness levels (7) Medicinal use of plant species (1) Informal harvesting (1)	Awareness campaigns held[a] (3) Environmental awareness levels (3)

IAS, invasive alien species; PES, payment for ecosystem services.
Numbers in parentheses denote the number of programs for which each parameter is valid.
[a] Input-based indicators.

Removing the "noise" created by the use of input-based indicators revealed that impact monitoring was very limited (Fig. 2). None of the 14 goals were monitored using outcome-based indicators in all programs where they appeared. In 64% of the cases, less than 50% of the programs backed their goals with impact monitoring. Five goals had no outcome-based indicator associated with them in any of the programs in which they were cited.

Discussion

Goals of Restoration

Restoration in South Africa is undertaken in a variety of contexts, driven by different socioeconomic and environmental agendas. As such, the goals of restoration incorporate both socioeconomic and ecological considerations. This is not surprising, considering the country's problems of widespread poverty and unemployment (Magadlela 2001), severe land degradation (Hoffman & Ashwell 2001), and the need to conserve biodiversity (Biggs et al. 2006). However, the setting of broad and/or qualitative restoration goals arguably poses the biggest problem to designing and implementing proper monitoring protocols. For example, the broad goal of "restoring natural capital" was cited in 70% of the programs assessed herein. Clewell and Aronson (2007) define restoring natural capital (RNC) succinctly as the replenishment of natural capital stocks in the interests of long-term human well-being and ecosystem health. Clearly, this is a complex goal, with multiple facets, the achievement of which would be very challenging to measure. Likewise, the qualitative goal of environmental awareness creation would be difficult to measure.

Moreover, the setting of a multitude of goals within single programs is also potentially problematic. This problem is often brought about by the setting of broad goals that inherently include some of the quantitative goals that have also been set. For example, in most of the programs assessed, poverty alleviation and livelihood improvement were meant to be achieved through job creation, but these were all stated as separate goals. Setting and attempting to achieve many goals within limited resources may result in insufficient monitoring of some, or even all the goals. It is, however, important to note that in order to secure funding goal setting is often a politically driven process. As a result, these sorts of catchy multiple and broad goals will occur (Funke & van Wyk 2007). The tension between broad politically appealing goals and narrow clearly defined goals desired by scientists can potentially be resolved by perhaps using the broad goals as "parent/header" goals for more detailed underlying aims in funding applications. The use of hierarchical goals (Tear et al. 2005) might avoid

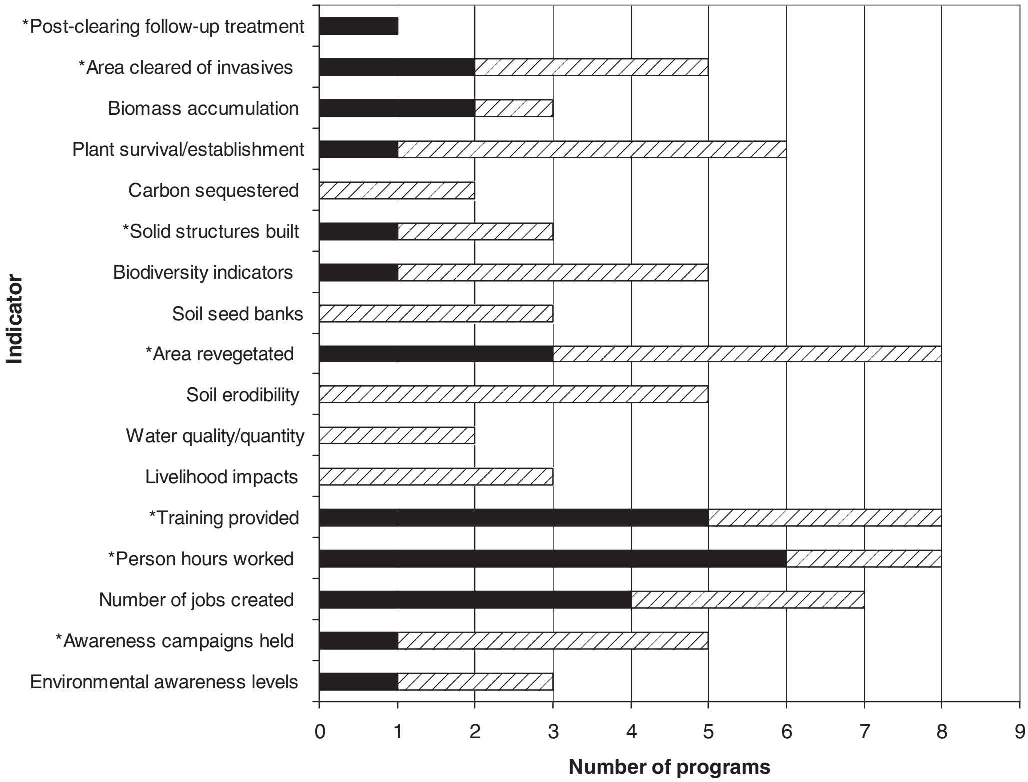

Figure 1. Types of indicators monitored (y-axis) and the number of programs in which they were monitored (x-axis). Solid black bars denote indicators that were monitored at all project sites within a particular program, whereas cross-hatched bars denote indicators that were monitored inconsistently, that is, at selected sites and/or as part of short-term studies. Asterisks denote input-based indicators.

goal redundancy which can result from setting a broad goal such as increasing resilience in conjunction with the goal of biodiversity conservation when the former can be reasonably expected to result from the latter (Chapin et al. 2000).

Baselines and Input-Based Indicators

The widespread collection of baseline information appeared to be one strong point in the practice of restoration in South Africa. However, we noted that sometimes this collection did not tie into the assessment of impact. For example, baseline information on water quality and/or quantity was collected in at least seven programs, but the impact of restoration on those indicators was only assessed in two programs. Moreover, the collection of more than one type of baseline indicator in association with a single goal suggests that some of the baseline data are either complementary or even redundant. This redundancy is evidenced by the fact that some of the baseline data were not related to any of the indicators monitored post-intervention. This common collection of redundant baseline data suggests inefficient use of resources.

Some redundancy was also observed in the types of indicators used in monitoring. This was apparent in instances where there were many indicators associated with a single goal, with the additional indicators being input-based. Indeed, the use of input-based indicators was widespread, thereby contributing to the incidence of what we termed “implementation” monitoring. When indicators are expressed in terms of implementation rather than post-implementation impact, the likelihood of perceiving the intervention as having been successful is high if implementation was done according to the set implementation plan. Alexander and Allan (2007) found this to be the case in some river restoration projects in the United States, where restoration was claimed to have been successful in more instances than was actually the case. This is a problem in South Africa too, with successful program implementation being confused with positive program impact (Beater et al. 2008; Holmes et al. 2008) or program success. The Society for Ecological Restoration lists some attributes of restored ecosystems (SER 2004). Despite having originally been described purely for ecological systems, it is our conviction that these attributes can be applied to socioecological systems, the arena within which restoration is practiced. One attribute of major importance is the ability of the restored system to self-sustain in the long term. This also implies that if benefits accruing from restoration are used to gauge success, then these should also accrue in a sustained manner for restoration to be regarded as having been successful. This requires monitoring well beyond the implementation or active phase of any restoration program. We recommend that managers, practitioners, and researchers work closely together to promote a culture of long-term and relevant monitoring.

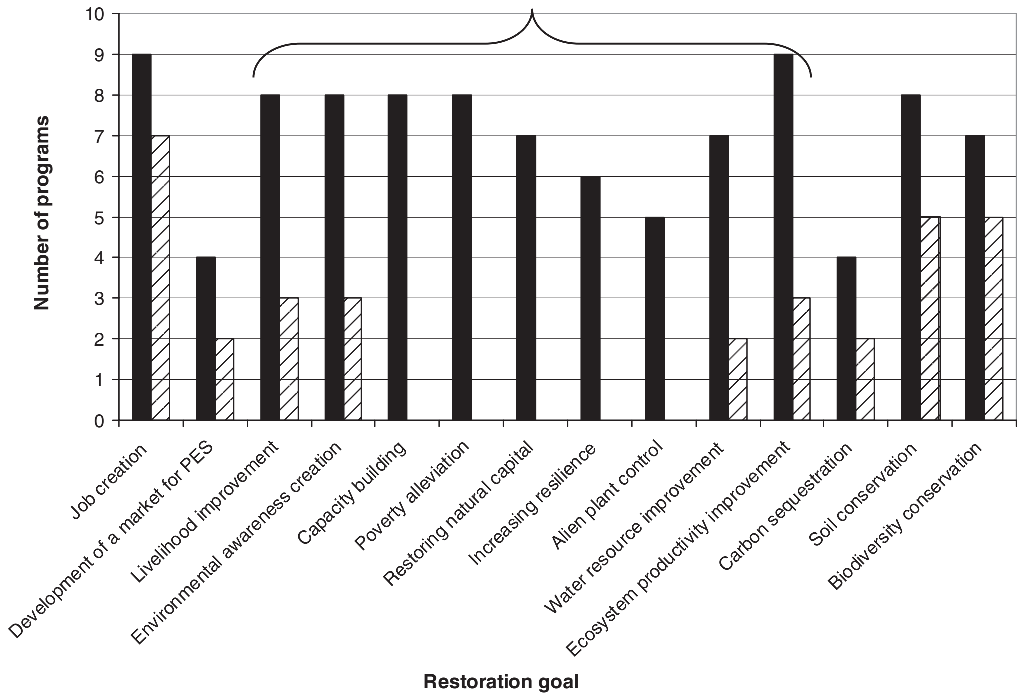

Figure 2. Incidence of impact monitoring. The black solid bars denote the number of programs (y-axis) citing the goals (x-axis). The cross-hatched bars denote the number of programs in which a corresponding, outcome-based indicator was monitored. Goals underneath the downward-facing brace were associated with impact monitoring in less than 50% of the programs in which they appeared.

Bias Toward Better Monitoring of Socioeconomic Indicators

The bias toward better and more consistent monitoring of socioeconomic indicators could be linked to the current absence of consensus surrounding the use of ecological indicators (Dale & Beyeler 2001). For example, biodiversity conservation is a common goal of most conservation and restoration programs globally, but a single method of measuring biodiversity status has not yet been agreed on and implemented, although several indices and approaches have been proposed (Noss 1990; UNEP 2003; Scholes & Biggs 2005). Similarly, there is no consensus on how to measure ecological integrity or ecosystem health (Cairns et al. 1993; Suter 1993; Andreason et al. 2001). In contrast, standard socioeconomic indicators (e.g. poverty, employment rate, and household income) have been in use for decades, if not centuries, to measure attributes of social systems. This is probably because these indicators are arguably more important to national accounts and economies. In addition, socioeconomic indicators are rooted in social sciences, which originated in the eighteenth century (Ross 1992). As such, they have become refined over time and their use has become relatively easy and standard practice. Advances are being made, however, in the development of ecological indicators (Balmford et al. 2005; Pereira & Cooper 2006; Scholes et al. 2008), rapid assessment techniques (Turner et al. 2003; Kennedy et al. 2009), and proxy measures (MA 2005; Eigenbrod et al. 2010). With time, the ease with which these can be applied is likely to increase, while at the same time reducing their costs. In the meantime, the onus is on the restoration practitioners to pay particular attention to clearly articulating the questions that monitoring aims to answer and validate the relationships between the chosen indicators and the restoration goals.

Secondly, the reality is that in South Africa environmental degradation is a minor consideration compared to poverty and related socioeconomic problems (RSA 2009). As such, a lot of government spending is geared toward addressing these latter problems. Indeed, four of the programs assessed herein are primarily poverty-alleviation projects, with ecological considerations being of secondary importance. This implies that the implementers' primary responsibility is to deliver on the socioeconomic goals, hence the bias toward more consistent and entrenched monitoring of socioeconomic indicators. Government-funded programs like the STRP are, however, an indication that the importance of environmental degradation, as well as its links to poverty and other socioeconomic targets, is increasingly being recognized and prioritized by the national government. This program includes a government-funded biome-wide plot experiment aimed to kick start restoration on a biome-scale. To date, over 300 plots (50×50–m) have been established spanning the entire biome, making it arguably the largest restoration experiment in the world, aiming to provide information to landowners across the biome on how to restore degraded land (Mills et al. 2010).

Monitoring constitutes continuous observation of an activity (or its outcomes) to keep track of trends and progress over time, and aims to identify the need for corrective action (Levendal et al. 2008). Although monitoring of ecological indicators was done in many of the programs assessed, it was mostly inconsistent in time and space, which could compromise its ability to detect trends and facilitate the implementation of corrective action where necessary. While recognizing that some systems take longer to recover, we advocate for monitoring at regular intervals in order to facilitate adaptive management. Careful attention therefore needs to be paid to the choice of indicators and monitoring intervals, depending on the system under consideration.

We also observed that sometimes ecological monitoring was not embedded within the programs themselves, but rather apportioned to the research projects associated with these programs. The problem with this approach is that in many instances research is conducted over short periods and monitoring is site-specific. Results from such inadequate monitoring can be misleading and have the potential to create the illusion that something substantial has been achieved at a wider scale. On the flip side however, it is a positive thing that researchers are involved in these programs. Indeed, research projects have been used as an excellent way of providing periodic and detailed assessments of the effectiveness of operations carried out by the likes of Working for Water (Magadlela 2001; Levendal et al. 2008; Buch & Dixon 2009) and Working for Wetlands (Kotze & Ellery 2008). However, we recommend that researchers also get engaged in the social process of strategy development and management, where they can ensure that long-term ecological monitoring is built into the restoration programs rather than being treated as an auxiliary activity. In addition, the involvement of local people in voluntary participatory monitoring could bring down the cost usually associated with monitoring done by professionals (Danielsen et al. 2007). Collaboration between managers, researchers, and volunteers would promote adaptive management, where monitoring would be linked back to management to ensure that results of monitoring are used to change approaches where necessary (Folke et al. 2005; Carpenter et al. 2009).

Evidence-based restoration makes sense because it reduces trial and error, facilitates learning from previous successes and failures, and subsequently leads to more efficient use of scarce resources through encouraging decision makers to weigh existing evidence for the effectiveness of a particular restoration intervention before implementing it. Proper goal setting, underpinned by knowledge of baseline conditions, and adequate monitoring are some of the basic building blocks of evidence-based practice. We propose three avenues that could be investigated to improve the current shortcomings in evidence-based restoration in South Africa:

(1) Decision makers need to pay careful attention to how many goals a single program aims to achieve and whether these goals are focused and measurable, while recognizing the need for political buy-in and funding for restoration (e.g. through the use of hierarchical goals and aims).

(2) Funders of restoration need to build in requirements for baseline information collection that is connected to relevant impact monitoring into their proposal processes. This would not necessarily require a significant commitment of funds if simple indicators, appropriate proxies, and rapid assessment techniques are used.

(3) There needs to be widespread merging of the science and practice of restoration, where practitioners and managers participate as scientists taking part in a real-world experiment and take interest in the science behind the practice, while scientists get involved in all aspects of the practice, especially planning. Positive strides have been made toward this ideal, with programs like the STRP and post-mining restoration having scientists, practitioners, and managers who do not draw a line between the science and the practice (Botha et al. 2008; Marais et al. 2009; Mills et al. 2010).

Ultimately, the advancement of evidence-based restoration will require a mind-shift among the decision makers, funders, practitioners, and researchers in restoration practice.

Implications for Practice

- Keep it simple. The setting of a few, clear, and realistic goals makes monitoring easier and ultimately improves the chances of success.
- Provisions for the collection of relevant baseline information and monitoring should be made during the planning stage of a restoration project.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. Short descriptions of the 10 programs used in the assessment.

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